

What is claimed is:

1. membrane device comprising:
 - a first membrane sheet and a second membrane sheet separated by a permeate carrier having an H-value of about 0.045 atm-sec/gm or less, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi applied pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.
2. The device of claim 1, wherein the H-value is about 0.040 atm-sec/gm or less.
3. The device of claim 1, wherein the H-value is about 0.035 atm-sec/gm or less.
4. The device of any of claims 1-3 wherein the thickness of the permeate carrier is approximately 0.013 inches or less.
5. The device of any of claims 1-3 wherein the thickness of the permeate carrier is approximately 0.020 inches or less.
6. The device of any of claims 1-3 wherein the thickness of the permeate carrier is approximately 0.025 inches or less.
7. The device of any of claims 1-6 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 15 or less.
8. The device of any of claims 1-6 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 15 - 25.
9. The device of any of claims 1-6 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 25 - 40.

10. The device of any of claims 1-6 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 40 or greater.
11. The device of any of claims 1-6 wherein the A value of each of the first
5 membrane sheet and the second membrane sheet is approximately 30.
12. The device of any of claims 1-11 wherein the first membrane sheet and the second membrane sheet define a leaf , wherein the leaf has a length of approximately 3 feet or less.
- 10 13. The device of any of claims 1-11 wherein the first membrane sheet and the second membrane sheet define a leaf , wherein the leaf has a length of approximately 3 feet to 5 feet.
- 15 14. The device of any of claims 1-11 wherein the first membrane sheet and the second membrane sheet define a leaf , wherein the leaf has a length of approximately 5 feet to 15 feet.
- 20 15. The device of any of claims 1-11 wherein the first membrane sheet and the second membrane sheet define a leaf , wherein the leaf has a length of approximately 15 feet or greater.
- 25 16. The device of any of claim 1-15 wherein the membrane device has β value of approximately 0.98 or greater.
17. The device of any of claim 1-15 wherein the membrane device has β value of approximately 0.95 to approximately 0.98.
18. The device of any of claims 1-15 wherein the membrane device has β
30 value of approximately 0.90 to approximately 0.95.
19. The device of any of claims 1-15 wherein the membrane device has β value of approximately 0.85 to approximately 0.90.

20. The device of any of claims 1-15 wherein the membrane device has β value of approximately 0.50 to approximately 0.85.

21. A membrane device comprising:

- 5 a first membrane sheet and a second membrane sheet separated by a permeate carrier having an H-value of 0.030 atm-sec/gm or less and a thickness of approximately 0.025 inches or less, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi applied pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

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22. A membrane device comprising:

- a first membrane sheet and a second membrane sheet separated by a permeate carrier having an H-value of 0.070 atm-sec/gm or less and a thickness of approximately 0.015 inches or less, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi applied pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

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23. A membrane device comprising:

- a first membrane sheet and a second membrane sheet separated by a permeate carrier having an H-value of 0.10 atm-sec/gm or less and a thickness of approximately 0.013 inches or less, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi applied pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

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25 24. A membrane device comprising:

- a first membrane sheet and a second membrane sheet separated by a permeate carrier having an H-value of 0.05 atm-sec/gm or less and a thickness of approximately 0.021 inches or less, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi applied pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

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25. The device of any of claims 21-24 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 15 or less.

26. The device of any of claims 21-24 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 15 - 25.
- 5 27. The device of any of claims 21-24 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 25 - 40.
28. The device of any of claims 21-24 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 40 - 60.
- 10 29. The device of any of claim 21-24 wherein the A value of each of the first membrane sheet and the second membrane sheet is approximately 60 or greater.
30. The device of any of claims 21-29 wherein the first and second
15 membranes define a leaf, wherein the leaf has a length of approximately 3 feet or less.
31. The device of any of claims 21-29 wherein the first and second membranes define a leaf, wherein the leaf has a length of approximately 3 feet to
20 5 feet.
32. The device of any of claims 21-29 wherein the first and second membranes define a leaf, wherein the leaf has a length of approximately 5 feet to
25 15 feet.
33. The device of any of claims 21-29 wherein the first and second membranes define a leaf, wherein the leaf has a length of approximately 15 feet or greater.
- 30 34. The device of any of claim 21-33 wherein the membrane device has β value of approximately 0.98 or greater.
35. The device of any of claim 21-33 wherein the membrane device has β value of approximately 0.95 to 0.98.

36. The device of any of claims 21-33 wherein the membrane device has β value of approximately 0.90 to 0.95.

5 37. The device of any of claims 21-33 wherein the membrane device has β value of approximately 0.85 to 0.90.

38. The device of any of claims 21-33 wherein the membrane device has β value of approximately 0.50 to 0.85.

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39. A home reverse osmosis system comprising:
a single leaf spiral wound membrane element which includes a first
membrane sheet and a second membrane sheet separated by a permeate carrier,
wherein the spiral wound membrane element has a diameter of approximately
15 2.0 inches or less and a length of approximately 12 inches or less, wherein the
membrane element is adapted to have a permeate flow rate of at least 150
gallons per day when tested with 500 ppm NaCl in DI water at 65 psi applied
pressure at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

20 40. The system of claim 39, wherein each of the membrane sheets has an A-
value of approximately 25 or greater.

41. The system of claims 39 or 40 wherein a net driving pressure of the
system is approximately 30 psi or less.

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42. The system of any of claims 39-41, wherein the NaCl rejection of the
device is at least 90% when tested with 500 ppm NaCl in DI water at 65 psi
applied pressure at 10 cm/s average feed channel cross-flow velocity at 77
degrees F.

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43. A tankless home reverse osmosis system comprising:
a membrane device including a single leaf structure which includes a first
membrane and a second membrane separated by a permeate carrier, wherein the
membrane device has a length of approximately 20 inches or less, each of the

membranes has an A-value of approximately 25 or greater, wherein the membrane device has a β value of at least about 0.60.

44. The system of claim 43, wherein the β value is at least about 0.80.

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45. The system of any of claims 43 and 44 wherein the device has a NaCl rejection of at least 90% when tested with 500 ppm NaCl in DI water at 65 psi at 10 cm/s average feed channel cross-flow velocity at 77 degrees F..

10 46. A high flow home reverse osmosis system comprising:
a membrane device including a single leaf structure which includes a first membrane and a second membrane separated by a permeate carrier, wherein the membrane device has an outer diameter of approximately 2.0 inches or less and a length of approximately 12 inches or less, wherein the membrane device has a
15 β value of at least about 0.90 and an A value of approximately 25 or greater.

47. The system of claim 46, wherein the membrane device has a β value of at least 0.95.

20 48. A membrane device comprising:
one or more leaves, each leaf including a first membrane sheet and a second membrane sheet separated by a permeate carrier, the one or more leaves having a total surface area of at least 350 square feet, wherein the element leaf length is greater than 42", wherein each of the membrane sheets has an A-value
25 of approximately 25 or greater; and
wherein the membrane element has a β value of at least 0.82
wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.

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49. The membrane device of claim 48, wherein the outer diameter of the membrane device is less than or equal to approximately 8 inches.

50. The membrane device of any of claims 48 or 49 wherein the length of each of the one or more leaves is approximately 5 feet or greater.
51. The membrane device of any of claims 48-50, wherein the membrane device has a β value of at least 0.90.
52. The membrane device of any of claims 48-51, wherein each of the membrane sheets has an A-value of approximately 25-35.
53. The membrane device of any of claims 48-51, wherein each of the membrane sheets has an A-value of approximately 35 - 60.
54. The membrane device of any of claims 48-51, wherein each of the membrane sheets has an A-value of approximately 60 or greater.
55. The membrane device of any of claims 48-54 wherein the membrane device includes 16 or fewer leaves.
56. The membrane device of any of claims 48-54 wherein the membrane device includes 4 or fewer leaves.
57. A membrane device comprising:
one or more leaves, each leaf including a firsts membrane sheet and a second membrane sheet separated by a permeate carrier, the one or more leaves having a total surface area of between 60 to 125 square feet, wherein the element leaf length is greater than 42", wherein each of the membrane sheets has an A-value of approximately 25 or greater; and
wherein the membrane element has a β value of at least about 0.82
wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.
58. The membrane device of claim 57, wherein the outer diameter of the membrane element is less than or equal to approximately 4 inches.

59. The membrane device of claims 57 or 58 wherein the length of each of the one or more leaves is approximately 5 feet or greater.
- 5 60. The membrane device of claim 57 wherein the device includes one to four leaves.
61. The membrane device of any of claims 57-60, wherein the membrane element has a β value of at least about 0.90.
- 10 62. The membrane device of any of claims 57-61, wherein each of the membrane sheets has an A-value of approximately 25-35.
63. The membrane device of any of claims 57-61, wherein each of the
15 membrane sheets has an A-value of approximately 35 - 60.
64. The membrane device of any of claim 57-61, wherein each of the membrane sheets has an A-value of approximately 60 or greater.
- 20 65. A membrane device comprising:
one or more leaves, each leaf including a pair of membrane sheets comprised of either two separate sheets or one sheet folded upon itself separated by a permeate carrier, the membrane element having an outer diameter greater than 8", wherein the element leaf length is greater than 42", wherein each of the
25 membrane sheets has an A-value of approximately 25 or greater; and wherein the membrane element has a β value of at least 0.82, wherein the membrane device is capable of at least 50% MgSO_4 rejection of 500 ppm MgSO_4 in DI water at 65 psi at 10 cm/s average feed channel cross-flow velocity at 77 degrees F.
- 30 66. The membrane device of claim 65 wherein the outer diameter of the element is greater than or equal to 12".

67. The membrane device of any of claims 65 or 66 wherein the length of each of the one or more leaves is approximately 5 feet or greater.

68. The membrane device of any of claims 65-67, wherein the membrane element has a β value of at least 0.90.

69. A membrane device including a single leaf structure which includes a pair of membrane sheets comprised of either two separate sheets or one sheet folded upon itself separated by a permeate carrier, wherein the membrane element has a length of approximately 20 inches or less, the membrane has an A-value of approximately 25 or greater, wherein the leaf length is at least 8 feet, wherein the membrane element has a β value of at least 0.75.

70. A membrane element including a double leaf structure, each leaf including a pair of membrane sheets comprised of either two separate sheets or one sheet folded upon itself separated by a permeate carrier, wherein the membrane element has a length of approximately 20 inches or less, the membrane has an A-value of approximately 25 or greater, wherein each leaf length is at least 3.5 feet, wherein the membrane element has a β value of at least 0.75.

71. The membrane element of claim 70, wherein the element includes a spiral wound configuration having an outer diameter of approximately 3.25 inches or less.

72. The membrane element of claim 70, wherein the salt retention of the membrane element is at least 90%.

73. The membrane element of claim 70, wherein the membrane sheets have an A-value of approximately 30 to 40.